



## Deep Rolling Apparatus of a Deep Rolling Machine for Crankshafts

The present invention relates to a deep rolling apparatus of a deep rolling machine for crankshafts where two arms across from each other support a deep rolling roller head or a supporting roller head, whereby the supporting roller head is provided with two supporting rollers with parallel axes and the deep rolling roller head with at least one deep rolling roller whose axis of rotation is in the same plane as the axis of rotation of the crankshaft and form an angle with it, with a driving device that produces the closing and opening motion of the deep rolling device as well as the deep rolling force.

A deep rolling apparatus of this type is known e.g. from DE 299 10 214.9 and DE 202 00 926.2. In either case the patents deal with deep rolling apparatuses provided with devices to avoid a collision of the tools with the lubricators of the crankshaft lobes. Normally, two deep rolling rollers are installed in pairs and at a distance from each other in a deep rolling roller head and enter the radii or indentation between the lobes and arms of the crankshaft under the action of the deep rolling force while the crankshaft rotates around its axis of rotation. The axes of rotation of the two deep rolling rollers in the same plane as the axis of rotation of the crankshaft or are slightly offset relative to the axis of rotation of the crankshaft. The deep rolling rollers are inclined outward in relation to the deep rolling roller head and also assume this with the axis of rotation of the crankshaft.

Inside the deep rolling the two deep rolling rollers bear on a guide roller head that is mounted in the deep rolling roller head in such manner that it cannot take over any forces in the longitudinal direction of the crankshaft.

Supporting roller heads may develop forces in axial direction, e.g. when the axis of one of the two supporting rollers of a supporting roller head is not exactly parallel with the axis of rotation of the crankshaft. In addition alignment errors in the alignment of the deep rolling tool, knocking of the crankshaft, conical bearing surfaces of the main or lobe bearing journal may provoke forces in axial direction, i.e. in the direction of the axis of rotation of the crankshaft that are undesirable due to incompatibility with a clean work

result and the intensity of which depends on the intensity of the deep rolling force and the existing conditions of friction.

This leads to the object of the present invention, consisting in providing a guiding system that is suitable to absorb forces emanating from the deep rolling apparatus or generated at the deep rolling apparatus in axial direction and thus to improve the machining results of deep rolling on the crankshaft.

According to the invention this object is attained in that an axial guide roller centered relative to the deep rolling head, having an axis of rotation perpendicular to the axis of rotation of the crankshaft and with a diameter that is slightly shorter than the distance between two lubricators of a main or lobe bearing journal of the crankshaft is provided in the scissor-like construction of the deep rolling roller head.

For an embodiment of the deep rolling apparatus of the less frequent compact design, whereby the two arms of the deep rolling apparatus are connected to each other via a yoke, an axial guide roller is installed on the yoke and is centered relative to the deep rolling roller head whose axis of rotation is perpendicular to the axis of rotation of the crankshaft and has a diameter that is slightly shorter than the distance between two lubricators of a main or lobe bearing journal of the crankshaft.

Since prevailing space availability usually does not permit a perpendicular positioning of the axial guide roller relative to the axis of rotation of the crankshaft, it is provided in another advantageous embodiment that the rotational axis of the axial guide roller forms a sharp angle with a plane containing the axis of rotation of the crankshaft and that is at a distance from the common plane of the rotational axes of the to supporting rollers. In both embodiments an axial guide roller delimiting an axial movement of the deep rolling apparatus in the longitudinal direction of the axis of rotation of the crankshaft is permanently installed therefore on the deep rolling roller head or on the yoke and introduces forces acting in the same direction into the lubricator of the crankshaft. The placement of the axial guide roller at a sharp angle does not affect the free space within

the deep rolling machine which may also be required for the axial displacement of the crankshaft. The placement instead leaves room free at the top that is of sufficient size to serve as an access space for a measuring scanner that measures the cyclic running of the crankshaft in a known matter before and after deep rolling.

Instead of a single axial guide roller, a pair of axial guide rollers is also provided, with axes of rotation parallel to each other and at a distance from each other. However the possibility is also provided for the axes of rotation of a pair of axial guide rollers to be offset as seen at an angle, perpendicularly to the axis of rotation of the crankshaft. Instead of axial guide rollers however, sliding bodies can also be provided in a known manner. Greatly advantageous embodiments are indicated in the sub-claims.

The invention is described in further detail through two examples of embodiments.

Fig. 1 shows a section through a deep rolling machine with a partial view of a crankshaft conveying device, whereby a deep rolling apparatus assumes its per-closing position relative to a presented crankshaft,

Fig. 2 shows a section through the deep rolling machine and a section through a main bearing journal of the crankshaft, whereby the deep rolling apparatus is in its closing position,

Fig. 3 shows a section along line IV-IV of Fig. 4,

Fig. 4 shows the axial guide roller on a deep rolling apparatus designed with the scissor-like construction,

Fig. 5 shows the cross-section through a deep rolling roller head,

Fig. 6 shows the force parallelogram of uniform axial forces,

Fig. 7 shows the force parallelogram of non-uniform axial forces and

Fig. 8 shows a second embodiment of a deep rolling apparatus.

A deep rolling machine 1 is designed with a driving device not shown serving to the reception of a crankshaft 3 presented by a crankshaft conveying device 2.

The driving device produces the rotational movement of the crankshaft 3 around its axis of rotation 4 during the deep rolling of the main axle journal 6 and lobe axle journal 5. The axis of rotation 4 is thus located in the axis of rotation of the driving device.

The present embodiment is made for the deep rolling of the lobe axle journal 5 of the crankshaft 3, since this is sufficient in order to explain the object of the invention. A deep rolling apparatus 8 of scissor-like construction provided with two scissor arms 9, 10, a scissor pivot point 11, a drive system 12, a deep rolling roller head 13 and a supporting roller head 14 is associated with the lobe axle journal 5. The drive system 12 is equipped with an adjusting cylinder 15 and a force device 16. The adjusting cylinder 15 generates the closing and opening movement of the deep rolling apparatus 8, the force device 16 produces the deep rolling force. The deep rolling apparatus 8 is hinged via a hinging point 17 to a rectangular lever 19 capable of swiveling around an axis 18. The rectangular lever 19 can be swiveled by means of a piston cylinder unit 20.

The deep rolling machine 1 is designed so that when the deep rolling apparatus 8 closes, the two supporting rollers 21, 22 of the supporting roller head 14 which have parallel axes and then the two deep rolling rollers 23, 24 of the deep rolling roller head 13 come to bear upon the lobe axle journal 5.

Hereby the supporting roller head 14 executes a swiveling motion 35 around the hinging point 17 and the deep rolling roller head 13 a swiveling motion 36 around the scissor pivot point 11.

During the swiveling motions 35 or 36 of the supporting roller head 14 and the deep rolling roller head 13 in the closing direction, a collision with one of the two lubricators 25, 26 of the lobe axle journal 5 is avoided because the deep rolling roller head 13 is provided with an axial guide roller 27 that is transversal and centered relative to the supporting rollers 21, 22 and has a diameter 28 greater than the width 29 of the deep rolling roller head 13 but slightly smaller than the distance 29a between the lubricators 25, 26 of the lobe axle journal 5.

The axial guide roller 27 is cylindrical on the outside. In the closed position of the deep rolling apparatus 8 Fig. 2 a clearance of approximately 0.25 mm is individually provided for the two free spaces 30, 31 between the lubricators 25, 26 and the axial guide roller 27.

The rotational axes 32 and 33 of the two supporting rollers 21 and 22 are in one and the same plane 34 which is at a distance  $s$  from a plane 38 containing the axis of rotation 4 of the crankshaft 3. The axis of rotation 7 of the axial guide roller 27 forms an acute angle 37 with the plane 38 containing the axis of rotation 4 of the crankshaft 3, is at a distance  $s$  from the common plane 34 of the axes of rotation 32 and 33 of the two supporting rollers 21 and 22 and is parallel.

The deep rolling apparatus shown in Fig. 4 corresponds to the deep rolling apparatus as shown in Figs. 1 and 2.

In the section through a deep rolling roller head as shown in Fig. 5, the deep rolling force 39 is exerted on the crankshaft 3 by the housing 4 via the guide roller 41 mounted rotatably therein and the deep rolling rollers 23 and 24. A representative force parallelogram is shown in Fig. 6 where the deep rolling force 39 is broken down into the two equal components 39' and 39''.

If an axial interference force 42 is exerted upon the housing 40 of the deep rolling roller head 13, a force parallelogram as in Fig. 7 is obtained. Therein the deep rolling force 39 is broken down into the two components 39''' and 39'''. The two components 39''' and 39''' are

39'''' are obviously of different magnitude. Applied back to the section of Fig. 5 this means that the left deep rolling roller 24 exerts a greater force 39''' on the crankshaft 3 than the right deep rolling roller 23 with component 39'''''. The result of the deep rolling operation is accordingly different.

In Fig. 8 another possible embodiment of a deep rolling apparatus is shown. Instead of scissor arms as those on which the embodiment of Figs. 1 to 4 is based, a deep rolling apparatus 49 in compact form is used here. Accordingly, the two arms 43 and 44 are connected to each other via a yoke 45. A lever system 46 with two articulations 47 and 48 as well as with a corresponding drive not shown ensures the swiveling of the deep rolling apparatus 49 into its work position. While the deep rolling head 13 is connected in a known manner to arm 43, the supporting roller head 50 is moved by a drive 51 into an opening and closing position relative to the crankshaft 3. An axial guide roller 52 projects from the yoke 45 in the direction of the axis of rotation of the crankshaft 3. The axial guide roller 52 is rotatably mounted in a base 53 on the yoke 45. The support of the axial guide roller 52 in the base 53 may either be rigid, as shown in Fig. 8, or can also have its own drive not shown that is similarly suited as in case of drive 51 to bring the axial guide roller 52 into a closing and opening position.

Instead of individual axial guide rollers 27 or 52, sliding elements can be provided and these, without being themselves rotatable, can be introduced into the intervals 29a between the two lubricators 25 and 26. Instead of individual rollers 27 or 52, pairs of rollers with diameters 28 considerably smaller than shown in Fig. 8, but with outer circumferences sufficient to bridge the distance 29a between the lubricators 25 and 26 can be provided. Here too, the principle applies again that instead of two individual axial guide rollers 27 or 52, sliding elements not shown are provided as known from DM GM 202 00 926.2.

The advantage of providing one axial guide roller 27, 52 on the deep rolling roller head 13 or on the yoke 45 of a deep rolling apparatus 8, 49 has the advantage over the known installation of one axial guide roller on the supporting roller head 14, that the axial

guidance of the deep rolling apparatus 8, 49 relative to the crankshaft 3 can be direct, so that possibly lacking rigidity in the device arm 9, 43 which supports the deep rolling roller head 13 as well as in the pivot point 11 between the two device arms 9, 10, 43, 44 can no longer affect the deep rolling results.

## List of Reference Numbers

- 1 Deep rolling machine
- 2 Crankshaft conveying device
- 3 Crankshaft
- 4 Rotational axis of the crankshaft
- 5 Lobe
- 6 Main bearing journal
- 7 Axis of rotation of the axial guide roller
- 8 Deep rolling apparatus
- 9 Scissor arm
- 10 Scissor arm
- 11 Scissor pivot point
- 12 Driving device
- 13 Deep rolling roller head
- 14 Supporting roller head
- 15 Adjusting cylinder
- 16 Force device
- 17 Hinging point
- 18 Axis
- 19 Rectangular lever
- 20 Piston-cylinder unit
- 21 Supporting roller
- 22 Supporting roller
- 23 Deep rolling roller
- 24 Deep rolling roller
- 25 Lubricator
- 26 Lubricator
- 27 Axial guide roller
- 28 Diameter of the axial guide roller
- 29 Width of the supporting roller head



29a	Distance between the lubricators
30	Free space
31	Free space
32	Axis of the supporting roller
33	Axis of the supporting roller
34	Plane through axes 32 and 33
35	Swivel motion, counterclockwise
36	Swivel motion, clockwise
37	Sharp angle
38	Plane
39	Deep rolling force
39'	Component of the deep rolling force
39''	Component of the deep rolling force
39'''	Component of the deep rolling force
39''''	Component of the deep rolling force
40	Housing
41	Guide roller
42	Axial interference force
43	Arm
44	Arm
s	Distance
45	Yoke
46	Lever system
47	Articulation
48	Articulation
49	Deep rolling apparatus
50	Supporting roller head
51	Drive
52	Axial guide roller
53	Base